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Best Demonstrated Available Technology (BDAT) Background Document for Organophosphorous Wastes (Proposed)

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This background document provides the agency's technical support for selecting and developing treatment standards for the constituents to be regulated in these organophosphorous wastes. For the K wastes, Section 2 presents waste-specific information--the number and location of facilities affected by the land disposal restrictions, the waste generating process, and the waste characterization data. Section 3 discusses the applicable and demonstrated technologies used to treat these wastes (or similar wastes). Section 4 presents the available performance data, including data on which the treatment standards are based. Section 5 explains EPA's determination of BDAT, while Section 6 discusses the selection of constituents to be regulated, and Section 7 presents treatment standards for these constituents. The P and U wastes are discussed in Section 8.

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PROPOSED

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

BACKGROUND DOCUMENT FOR

ORGANOPHOSPHOROUS WASTES

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1. INTRODUCTION

Pursuant to section 3004(m) of the Resource Conservation and Recovery Act (RCRA) as enacted by the Hazardous and Solid Waste Amendments (HSWA) on November 8, 1984, the Environmental Protection Agency (EPA) is proposing treatment standards based on the best demonstrated available technology (BDAT) for the waste treatability group identified as organophosphorous wastes. These wastes are identified in 40 CFR 261.32 as K038, K039, and K040; in 40 CFR 261.33, they are identified as P039, P040, P041, P043, P044, P062, P071, P085, P089, P094, P097, P109, P111, U058, U087, and U235. The Agency is also proposing standards for the wastewater forms of K036. A treatment standard of "No Land Disposal Based on No Generation" was promulgated for the nonwastewater forms of K036 on August 8, 1988. Compliance with these BDAT treatment standards is a prerequisite for the placement of these wastes in units designed as land disposal units according to 40 CFR Part 268. The proposed effective date of these treatment standards is June 8, 1989.

This background document provides the Agency's technical support for selecting and developing treatment standards for the constituents to be regulated in these organophosphorous wastes.

For the K wastes, Section 2 presents waste-specific information--the number and location of facilities affected by the land disposal restrictions, the waste generating process, and the waste characterization data. Section 3 discusses the applicable and demonstrated technologies used to treat these wastes (or similar

wastes). Section 4 presents the available performance data, including data on which the treatment standards are based. Section 5 explains EPA's determination of BDAT, while Section 6 discusses the selection of constituents to be regulated, and Section 7 presents treatment standards for these constituents. The P and U wastes are discussed in Section 8.

The BDAT program and promulgated methodology are more thoroughly described in the two additional documents: Methodology for Developing BDAT Treatment Standards (USEPA 1988c) and Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") (USEPA 1987). The petition process that must be followed when requesting a variance from the BDAT treatment standards is discussed in the methodology document.

The Agency is regulating one organic constituent, phorate, in both the nonwastewater and wastewater forms of the organophosphorous wastes. For the purpose of determining the applicability of the treatment standards, wastewaters are defined as wastes containing less than 1 percent (weight basis) total suspended solids* and less than 1 percent (weight basis) total organic carbon (TOC). Wastes not meeting this definition must comply with the treatment standards for nonwastewaters.

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* The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, total suspended solids is measured by Method 209c (Total Suspended Solids Dried at 103 to 105°C) in Standard Methods for the Examination of Water and Wastewater (APHA, AWWA, and WPCF 1985).

BDAT level of performance standards for wastewaters and nonwastewaters for K038, K040, P039, P071, P089, P094, P097, and U235, have been transferred from the treatment standards established for the wastewater treatment sludge from the production of disulfoton (K037). These treatment standards were promulgated based on total concentration analyses of the waste, the ash residues, and the scrubber water generated during rotary kiln incineration of K037 waste. If the concentrations of the regulated constituents, as generated, are lower than or equal to the proposed BDAT treatment standards, then treatment is not necessary as a prerequisite to land disposal. Additionally, the Agency is proposing technology-based standards for the wastewater and nonwastewater forms of K039, P040, P041, P043, P044, P062, P085, P109, P111, U058, and U087.

Table 1-1 presents the proposed treatment standards for the organophosphorous wastes.

Table 1-1 Treatment Standards for the Organophosphorous Wastes

Waste code	Regulated constituent	Wastewaters (ppm)	Nonwastewaters (ppm)
K038	Phorate	0.003	0.10
K039	-[a]	Carbon Adsorption	Incineration
K040	Phorate	0.003	0.10
P039	Disulfoton	0.003	0.10
P040	-[a]	Carbon adsorption	Incineration
P041	-[a]	Carbon adsorption	Incineration
P043	-[a]	Carbon adsorption	Incineration
P044	-[a]	Carbon adsorption	Incineration
P062	-[a]	Carbon adsorption	Incineration
P071	Methyl parathion	0.003	0.10
P085	-[a]	Carbon adsorption	Incineration
P089	Parathion	0.003	0.10
P094	Phorate	0.003	0.10
P097	Famphur	0.003	0.10
P109	-[a]	Carbon adsorption	Incineration
P111	-[a]	Carbon adsorption	Incineration
U058	-[a]	Carbon adsorption	Incineration
U087	-[a]	Carbon adsorption	Incineration
U235	Tris-(2,3-Dibromopropyl) phosphate	0.003	0.10

[a]For this waste code, EPA is not regulating a specific constituent level but instead is proposing a technology that must be used to treat the wastes.

2. INDUSTRY AFFECTED AND WASTE CHARACTERIZATION

This section describes the industry affected by the land disposal restrictions for K038, K039, and K040 and presents available characterization data for these wastes.

Under 40 CFR 261.32, wastes identified as K038, K039, and K040 are specifically generated in the production of phorates. These wastes are listed as follows:

K038: Wastewater from the washing and stripping of phorate production.

K039: Filter cake from the filtration of diethylphosphorodithioic acid in the production of phorate.

K040: Wastewater treatment sludge from the production of phorate.

The Agency has examined the source of the wastes, specific similarities in waste composition, applicable and demonstrated treatment technologies, and attainable treatment performance in order to support the approach proposed for these listed wastes.

2.1 Industry Affected and Process Description

The four-digit Standard Industrial Classification (SIC) code associated with the production of phorates is 2818 (Organic Pesticide Products). The Agency believes that only one facility currently produces phorates and generates K038 and K039 wastes. This facility is located in EPA Region VII in the State of Missouri. Based on the National Survey of Hazardous Waste Treatment, Storage, Disposal, and Recycling Facilities of 1986 (the TSDR Survey), the Agency believes that K040 is no longer generated. Nevertheless, EPA has decided to set BDAT treatment standards for this waste as well.

The production of phorates typically consists of the reaction of O,O-diethyl hydrogen phosphorodithioate with formaldehyde, followed by the addition of ethyl mercaptan (ethanethiol). The O,O-diethyl hydrogen phosphorodithioate is condensed with formaldehyde and ethyl mercaptan.

The reaction chemistry is as follows:

$$P_2S_5 \text{ (phosphorous pentasulfide)} + 4C_2H_5OH \text{ (ethanol)} \longrightarrow 2(C_2H_5O)_2PSH \text{ (O,O-diethyl hydrogen phosphorodithioate)} + H_2S$$

$$(C_2H_5O)_2PSH \text{ (O,O-diethyl hydrogen phosphorodithioate)} + H_2C{=}O \text{ (formaldehyde)} \longrightarrow (C_2H_5O)_2PS\text{-}CH_2OH \text{ (dithiophosphate)}$$

$$(C_2H_5O)_2PS\text{-}CH_2OH \text{ (dithiophosphate)} + C_2H_5SH \text{ (ethyl mercaptan)} \longrightarrow (C_2H_5O)_2P\text{-}SCH_2SC_2H_5 \text{ (phorate)} + H_2O$$

Three hazardous waste streams are expected to be generated from the production of phorate:

1. Process wastewater (K038), which is likely to contain significant concentrations of phorate and lesser concentrations of other process waste constituents including formaldehyde, phosphorodithioic and phosphorothioic acid esters, and other main reaction byproducts;

2. A filter cake (K039), which is expected to contain high concentrations of esters of phosphorodithioic acid and esters of phosphorothioic acid; and

3. Wastewater sludges (K040) resulting from the treatment of process waters. These sludges are expected to contain high concentrations of phorate because of its relative insolubility in water. Lesser concentrations of other process constituents are also expected to be found in the sludge.

Figure 2-1 illustrates the sources of these waste streams of concern.

2.2 Waste Characterization

This section provides all waste characterization data obtained by the Agency for K038, K039, and K040. Tables 2-1, 2-2, and 2-3 present, by waste code, the BDAT list constituents and other parameters identified for each waste. The K038 wastes are expected to contain phorate, phosphorodithioic acid esters, phosphorothioic acid esters, and formaldehyde. As seen on Table 2-1, the concentration of phorate, an organophosphorous insecticide, is 50 ppm. No BDAT list constituents, except phorate, were detected at treatable concentrations in the untreated K038 waste sample. The K039 wastes contain phosphorodithioic acid esters and phosphorothioic acid esters. While these are Appendix VII constituents, they are not part of the BDAT list because they currently cannot be analyzed at the treated concentrations. Therefore, EPA could not enforce any proposed quantitative regulation for these constituents. The K040 waste contains phorate, formaldehyde, phosphorodithioic acid triethyl ester, and phosphorothioic acid triethyl ester. As seen on Table 2-3, the concentration of phorate in the waste is 2,500 ppm. No other BDAT list constituent is expected to be present in the untreated waste.

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Figure 2-1. Phorate Production

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Table 2-1 Available Characterization Data for K038

	Untreated waste concentration
BDAT List Organics	
Organophosphorous Insecticides	
Phorate	50.0 ppm
Other Organics	
Phosphorothioic acid esters	0.5 ppm
Phosphorodithioic acid esters	5.0 ppm
Formaldehyde	5.0 ppm
Other Constituents	
Water[a]	>99 %

[a]K038 is an aqueous waste, whose only other constituent is expected to be water. This characteristic was not specifically stated on the data source, however.

Reference: Environ Corporation. n.d.

Table 2-2 Available Characterization Data for K039

	Untreated waste concentration
Non-BDAT List Organics	
Phosphorodithioic acid triethyl esters	10%
Phosphorothioic acid triethyl esters	1%
Other Constituents	
Water[a]	89%

[a]K039 is a non-aqueous waste, whose only other constituent is expected to be water. This characteristic was not specifically stated on the data source, however.

Reference: Environ Corporation. n.d.

Table 2-3 Available Characterization Data for K040

	Untreated waste concentration
BOAT List Organics	
Organophosphorous Insecticides	
Phorate	2,500 ppm
Other Organics	
Phosphorodithioic acid triethyl esters	21,000 ppm
Phosphorothioic acid triethyl esters	2,000 ppm
Formaldehyde	300 ppm
Other Constituents	
Water[a]	>97%

[a]K040 is a non-aqueous waste, whose only other constituent is expected to be water. This characteristic was not specifically stated on the data source, however.

Note: It appears that this waste is no longer produced.

Reference: Environ Corporation. n.d.

Characterization data identified in the literature for K038, K039, and K040 do not provide values for concentrations of BDAT list metals. There is no reason to suspect that BDAT list metals are present in these wastes.

2.3 Determination of Waste Treatability Group

If EPA believes that the same technologies can be used to treat constituents present in wastes represented in different codes to similar concentrations, the Agency may combine the codes into one separate treatability group.

Based on review of the generation of phosphate and phosphorothioate pesticides, the waste compositions, and all available data characterizing the wastes produced in this process, the Agency has determined that K038, K039, and K040 wastes represent a single waste treatability group. Although the concentrations of specific constituents will vary from one waste code to another, all of these wastes contain similar constituents and are expected to be treatable to similar levels using the same technologies. Consequently, EPA has examined the sources and characteristics of these wastes, their applicable and demonstrated treatment technologies, and their attainable treatment performance in order to determine a single regulatory approach that would be applicable for these wastes.

Even though the K039 wastewater constituents are similar to those in K038 and K040 wastewaters, the Agency is proposing the best available

demonstrated technology (BDAT) to be different from the BDAT proposed for the K038 and K040 wastewater because EPA has no approved method that can adequately analyze diethyl phosphorodithioic acid in treatment residues. In addition, EPA has not identified any organic constituents in K039 wastes that could be used as a surrogate or as an indicator compound in order to develop numerical standards for K039 wastes.

3. APPLICABLE AND DEMONSTRATED TREATMENT TECHNOLOGIES

This section identifies the treatment technologies that are applicable to this group and determines which, if any, of the applicable technologies can be considered demonstrated for the purpose of establishing BDAT.

To be applicable, a technology must be theoretically usable to treat the waste in question, or to treat a waste that is similar in terms of the parameters that affect treatment selection. (For detailed descriptions of the technologies applicable for these wastes, or for wastes judged to be similar, see EPA's Treatment Technologies Background Document (USEPA 1988d).) To be demonstrated, the technology must be employed in full-scale operation for the treatment of the waste in question or a similar waste. Technologies that are available only at research facilities or at pilot- and bench-scale operations are not considered in identifying demonstrated technologies.

3.1 Applicable Treatment Technologies

Since K038, K039, and K040 contain organics, the technologies applicable to the untreated listed wastes should include those that destroy or reduce the total amount of various organic compounds in the waste.

The Agency has identified incineration as an applicable treatment technology to treat K038, K039, and K040 wastes. While K038 is a wastewater by definition, the only known generator incinerates this waste. Technologies such as fuel substitution, biological treatment, and solvent extraction also may be applicable to the treatment of the

above-mentioned wastes as generated. In addition, the Agency believes that wet air oxidation and carbon adsorption may be applicable for K038 and the wastewater forms of K039 and K040. Although EPA has not identified any facilities that use wastewater treatment technologies on the listed or similar wastes, there is no information to suggest that any of these wastewater treatment technologies noted above are not applicable to wastes similar to K038 and to the wastewater forms of K039 and K040.

Incineration is a destruction technology in which energy, in the form of heat, is transferred to the waste to destabilize chemical bonds and eventually destroy hazardous constituents by converting them to carbon dioxide, water, and other oxidized waste constituents. In general, the two residuals generated by incineration processes are ash and combustion gas scrubber water.

The Agency has identified carbon adsorption as an applicable technology for the wastewater forms of K039. EPA believes that diethyl phosphorodithioic acid esters, the organic constituents in K039 wastewaters, can easily be adsorbed on carbon because of the chemical and physical properties of the compounds (such as their molecular weight, elemental compositions, and structural forms).

3.2 Demonstrated Treatment Technologies

Of the above-mentioned technologies applicable for BDAT list organic constituents, the Agency believes that incineration is demonstrated to treat K038 and K039, since this technology is currently being used by one facility to treat such wastes.

The Agency has not identified any facilities using incineration for treatment of K040 waste. However, since incineration is a widely demonstrated treatment technology for wastes containing BDAT list organics and it is being used to treat wastes similar to K040 (e.g., K037: Wastewater treatment sludge from the production of disulfoton), the Agency considers incineration to be a demonstrated technology for K040 wastes.

The Agency considers carbon adsorption to be a demonstrated technology for K039 wastewaters, since carbon adsorption is being used to treat constituents with characteristics similar to diethyl phosphorodithioic acid esters.

4. PERFORMANCE DATA BASE

This section presents the data available on the performance of demonstrated technologies in treating the listed wastes. These data are used elsewhere in this document for determining which technologies represent BDAT (Section 5), for selecting constituents to be regulated (Section 6), and for developing treatment standards (Section 7). Eligible data may include data developed at bench- or pilot-scale facilities or obtained through other applications at less than full-scale operation, as long as the technology is demonstrated in full-scale operation for a similar waste or wastes.

Performance data, to the extent that they are available to EPA, include the untreated and treated waste concentrations for a given constituent, the values of operating parameters that were measured at the time the waste was being treated, the values of relevant design parameters for the treatment technology, and data on waste characteristics that affect performance of the treatment technology.

Where data are not available on the treatment of the specific wastes of concern, the Agency may elect to transfer data on the treatment of a similar waste or wastes, using a demonstrated technology. To transfer data from another waste category, EPA must find that the wastes covered by this background document are no more difficult to treat (based on the waste characteristics that affect performance of the demonstrated treatment technology) than the treated wastes from which performance data are being transferred.

The Agency has no data to characterize treatment for K038, K039, or K040 wastes; however, the Agency has a data base for incineration of a similar waste (K037), which, according to 40 CFR 261.32, is listed as wastewater treatment sludge from the production of disulfoton. Performance concentration levels for K037 wastewaters and nonwastewaters have already been promulgated (53 FR 31157, August 17, 1988). These standards were based on the performance of incineration of K037 nonwastewaters in a rotary kiln and the concentration of hazardous constituents found in the ash and scrubber water residuals.

The similarity between the K038, K039, and the K040 wastes and the K037 waste is based on the production processes, the waste compositions, and the similarity of the waste characteristics affecting treatment performance. In addition, phorate's chemical structure is very similar to that of disulfoton. As seen on Figures 4-1 and 4-2, the only difference in chemical structure is the additional methylene ($-CH_2-$) group in disulfoton. This difference is believed to be insignificant with respect to how well these two pesticides incinerate. Consequently, the Agency is transferring performance data directly from the treatment of K037 to the K038 and K040 wastes.

Tables 4-1 through 4-6 of the Best Demonstrated Available Technology (BDAT) Background Document for K037 (USEPA 1988a) present the six data sets of total waste concentration analyses for K037 waste samples and the design and operating data for the incineration treatment system. As shown by the operating data taken during sample collection, all six data

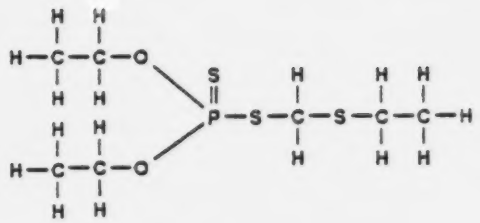


FIGURE 4-1 PHORATE

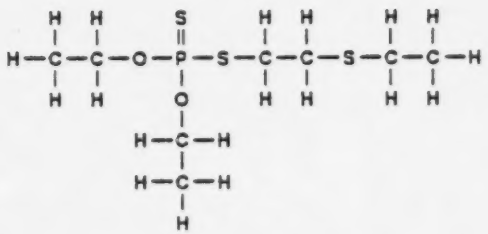


FIGURE 4-2 DISULFOTON

sets reflect treatment by a well-operated system. Furthermore, all the data sets show that the organic BDAT list constituents detected in the untreated wastes are treated to nondetectable levels in the treatment residuals.

Based on the engineering analyses presented in Characterization of Pesticide Manufacturing Wastes (Radian 1984), a study performed by the Agency to establish information on hazardous wastes and management of phorate (the proposed K038 and K040 constituent), EPA has no reason to believe that metals are present in significant concentrations in the untreated K038 and K040 wastes.

5. IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY

This section presents the Agency's rationale for the determination of best demonstrated available technology (BDAT) for K038, K039, and K040 nonwastewaters and wastewaters. BDAT must be specifically defined for all streams associated with the management of the listed waste or wastes; this pertains to the original waste as well as to any residual waste streams created by the treatment process.

To determine BDAT, the Agency examines all available performance data on technologies that are identified as demonstrated to determine (using statistical techniques) whether one or more of the technologies performs significantly better than the others. In addition, all performance data used for determination of best technology are first adjusted for accuracy, as discussed in EPA's publication Methodology for Developing BDAT Treatment Standards (USEPA 1988c). (An accuracy adjustment accounts for the ability of an analytical technique to recover a particular constituent from the waste in a particular test. The recovery of a constituent is usually determined by spiking a raw waste sample with a known amount of the target constituent and then comparing the amount recovered with results from unspiked samples of the waste.)

The technology that performs best on a particular waste or waste treatability group is then evaluated to determine whether it is "available." To be available the technology must (1) be commercially available to any generator and (2) provide "substantial" treatment of the waste, as determined through evaluation of accuracy-adjusted data. In

determining whether treatment is substantial, EPA may consider data on the performance of a waste similar to the waste in question provided that the similar waste is at least as difficult to treat. If the best technology is found to be not available, then the next best technology is evaluated, and so on.

The Agency is proposing BDAT treatment standards based on hazardous constituent concentrations for the wastewater and nonwastewater forms of K038 and K040. As previously discussed, the Agency currently is not able to analyze any constituent of the K039 waste in treatment residues; thus, it is proposing technology-based standards for the wastewater and nonwastewater forms of this waste.

5.1 Nonwastewaters

The nonwastewater streams are the K039 and K040 raw wastes to be incinerated. Consistent with EPA's methodology for determining BDAT, the Agency evaluated the incineration performance data for the similar waste (K037) to determine whether this technology would provide statistically significant treatment for BDAT list organic constituents in the above-mentioned wastes. Based on the evaluation of the design and operating parameters of the treatment system, the analytical testing, and the quality of the data, EPA determined that statistically significant treatment does occur. This determination is based on the fact that the BDAT list organic constituents were reduced to nondetectable levels in the treatment residuals. Incineration is also a widely available commercial technology. Consequently, the Agency concluded that incineration alone is BDAT for the raw wastes.

Performance data for a similar waste (K037) indicated that organic residuals in the ash and the scrubber water were below detection limits. The Agency concluded that there is no need for additional treatment of nonwastewater or wastewater residuals resulting from incineration of K037 and that incineration alone is BDAT for all nonwastewaters associated with the treatment of this waste. Since K039 and K040 are similar to K037, the Agency likewise concluded that incineration is demonstrated and was selected for determination of BDAT treatment standards for all nonwastewaters associated with the treatment of K039 and K040 wastes. As with K037 treatment residuals, the Agency concluded that there is no need for additional treatment of nonwastewater and wastewater residuals of K039 and K040 treated wastes.

5.2 Wastewaters

Treatment of K038 and K040 in an incinerator produces one wastewater residual stream--scrubber water from the incinerator's air pollution control equipment. The performance test developed for a similar waste (K037) indicated that concentrations of BDAT list organic constituents in scrubber water from incineration were below detection limits. The Agency concluded that no additional treatment of scrubber water would significantly improve upon this performance. Therefore, incineration alone was chosen as BDAT for K037. Hence, the Agency is proposing incineration as BDAT for K038 and K040 wastewaters, since these wastes are similar to K037.

The Agency proposes carbon adsorption to be BDAT for the wastewater residual forms of K039. EPA believes that diethyl phosphorodithoic acid in wastewater forms of K039 can easily be adsorbed on carbon due to the chemical and physical properties of the compound (such as its molecular weight, elemental composition, and structural form). Additionally, the Agency considers the spent carbon to be a nonwastewater form of K039, which needs to be incinerated in the same manner as is proposed for the K039 nonwastewaters in Section 5-1.

6. SELECTION OF REGULATED CONSTITUENTS

This section presents the rationale for the selection of regulated constituents for the treatment of K038, K039, and K040 wastes.

Constituents selected for regulation must satisfy the following criteria:

1. They must be on the BDAT list of regulated constituents. (Presence on the BDAT list implies the existence of approved techniques for analyzing the constituent in treated waste matrices.)

2. They must be present in, or be suspected of being present in, the untreated waste. For example, in some cases, analytical difficulties (such as masking) may prevent a constituent from being identified in the untreated waste, but its identification in a treatment residual may lead the Agency to conclude that it is present in the untreated waste.

3. Where performance data are transferred, the selected constituents must be easier to treat than the waste constituent(s) from which performance data are transferred. Factors for assessing ease of treatment will vary according to the technology of concern. For instance, for incineration the factors include bond dissociation energy, thermal conductivity, and boiling point.

From the group of constituents that are eligible to be regulated, EPA may select a subset of constituents as representative of the broader group. For example, out of a group of constituents that react similarly to treatment, the Agency might name only those that are the most difficult to treat as regulated constituents for the purpose of setting a standard.

6.1 Identification of BDAT List Constituents

As discussed in Sections 2 and 4, the Agency has characterization data for K038, K039, and K040, as well as performance data from treatment of a similar waste (K037). These data, along with information on the

waste generating process, have been used to determine which BDAT list constituents may be present in the waste and thus which are potential candidates for regulation in K038, K039, and K040 wastes. Constituents that were not expected to be in the untreated waste were not considered for regulation.

6.2 Constituent Selection

Since there are no treatment performance data from incineration of K038, K039, and K040, the Agency has transferred performance data from the treatment of K037 at plant A (USEPA 1988a) to the above-listed wastes. This transfer of treatment data is supported both by the determination that all of these wastes are generated by the organophosphorous industry and by the Agency's belief that constituents present in K038 and K040 are similar to those in K037, and thus are amenable to the same treatment technology.

The determination of adequate control for the constituents was based on an evaluation of the characteristics of the constituents (i.e., the boiling point and the bond dissociation energy) that would affect the performance of incineration. In general, a constituent with a low boiling point and low dissociation energy would be easier to treat by incineration than would constituents with higher boiling points and higher dissociation energies.

The constituent having the same or the closest higher boiling point and bond dissociation energy, for which the Agency had treatment performance data from K037 at plant A, was selected for transfer of data.

Phorate is the only BDAT list constituent expected to be present in K038 and K040 wastes. It also has characteristics similar to disulfoton, the constituent treated and regulated in the similar waste (K037). Table 6-1 presents the constituent characteristics that affect the performance of incineration for the K037 regulated constituent (disulfoton), from which the standards are being transferred, and for the K038 and K040 constituent to be regulated (phorate). As can be seen in this table, the boiling point and the bond dissociation energy values of phorate are lower than the values for disulfoton. This condition indicates that phorate should be easier to incinerate than disulfoton.

Based on the discussion of waste characteristics affecting treatment performance of incineration in the Treatment Technologies Background Document, the Agency expects that phorate can be treated to concentration levels as low as or lower than disulfoton.

Phorate is not present in K039 and no methods are currently available to analyze the constituents present in this waste in treatment residues. However, since these constituents are structurally similar to phorate and are generated during its production, the Agency has determined that incineration is BDAT for this waste, as noted in Section 5. Because the K039 constituents cannot be analyzed at the treated levels, however, the Agency is only setting a technology standard, not a performance concentration level.

Table 6-2 shows the BDAT list constituents that were selected by the Agency to regulate K038, K039, and K040 wastes.

Table 6-1 Waste Characteristics Affecting Performance of Incineration

Constituent	Waste code	Boiling point	Bond dissociation energy (Kcal/mol)
Disulfoton	K037	132° - 133°C(1.5mm Hg)[a]	2860
Phorate	K038, K040	125° - 127°C(2.0mm Hg)[a]	2755

[a] Merck and Co., 1983.

Table 6-2 Regulated Constituents for K038, K039, and K040

Waste code	Regulated constituent
K038	Phorate
K039	None
K040	Phorate

7. DEVELOPMENT OF BDAT TREATMENT STANDARDS

The Agency bases treatment standards for regulated constituents on the performance of well-designed and well-operated BDAT treatment systems. These standards must account for analytical limitations in available performance data and must be adjusted for variabilities related to treatment, sampling, and analytical techniques and procedures.

BDAT standards are determined for each constituent by multiplying the arithmetic mean of accuracy-adjusted constituent concentrations detected in treated waste by a "variability factor" specific to each constituent. Accuracy adjustment of performance data was discussed in Section 5 in relation to defining "substantial treatment." Variability factors correct for normal variations in the performance of a particular technology over time. They are designed to reflect the 99th percentile level of performance that the technology achieves in commercial operation. (For more information on the principles of calculating variability factors, see EPA's publication, Methodology for Developing BDAT Treatment Standards. For details on the calculation of variability factors for K038 and K040 wastes, see Appendix A of the Best Demonstrated Available Technology (BDAT) Background Document for K037 (USEPA 1988a).

Where EPA has identified BDAT for a particular waste, but because of data limitations or some other compelling reason cannot define specific treatment standards for that waste, the Agency can require the use of that treatment process as a technology standard. Similarly, where there

are no known generators of a waste, or where EPA believes that the waste can be totally recycled or reused as a raw material, the Agency may specify a "no land disposal" standard, which effectively amounts to setting the performance standard at zero for all waste constituents.

In the case of K038 and K040, the Agency is setting wastewater and nonwastewater treatment standards for the regulated constituent as shown in Tables 7-1 and 7-2. The Agency is not setting concentration treatment standards for K039; instead, it is establishing technology-based standards for this waste consisting of incineration for nonwastewaters and carbon adsorption for wastewaters, as explained in Section 6.2.

Additionally, the Agency is also proposing to set treatment standards for the wastewater forms of K036. The treatment standards for the nonwastewater forms were already promulgated on August 8, 1988 (USEPA 1988b). The Agency proposes a direct transfer of concentration performance treatment standards for K036 (still bottoms from toluene reclamation distillation in the production of disulfoton) from K037 wastewaters from the production of disulfoton for the same constituent of concern-disulfoton. Therefore, the Agency is proposing incineration as BDAT for K036 wastewaters. The proposed treatment standards for K036 wastewaters, directly transferred from K037 wastewaters, is 0.003 mg/l of disulfoton.

Table 7-1 BDAT Nonwastewater Treatment Standards for K038 and K040

Regulated constituents (SW-846 Method No.)[a]	K037 const. from which treat. data were transferred	Untreated conc. in K037 (ppm)	Arithmetic average of corrected treat. values (ppm)	Variability factor (VF)	Treatment standard (Ave. x VF) (ppm)
Organophosphorous Insecticide					
Phorate (8140, 8270)	Disulfoton	104,000-246,000	0.04	2.8	0.1

[a]USEPA 1986a.

Table 7-2 BDAT Wastewater Treatment Standards for K038 and K040

Regulated constituents (SW-846 Method No.)[a]	K037 const. from which treat. data were transferred	Untreated conc. in K037 (ppm)	Arithmetic average of corrected treat. values (ppm)	Variability factor (VF)	Treatment standard (Ave. x VF) (ppm)
Organophosphorous Insecticide					
Phorate (8140, 8270)	Disulfoton	104,000-246,000	0.0011	2.8	0.03

[a]USEPA 1986a.

Table 7-2 BDAT Wastewater Treatment Standards for K038 and K040

Regulated constituents (SW-846 Method No.)[a]	K037 const. from which treat. data were transferred	Untreated conc. in K037 (ppm)	Arithmetic average of corrected treat. values (ppm)	Variability factor (VF)	Treatment standard (Ave. x VF) (ppm)
Organophosphorous Insecticide					
Phorate (8140, 8270)	Disulfoton	104,000-246,000	0.0011	2.8	0.03

[a]USEPA 1986a.

8. P AND U WASTE CODES

This section describes regulations for the organophosphorous P and U wastes that are similar to K038, K039, and K040. The following wastes have been grouped together because of the similarities in structure and elemental content of the primary constituent of concern in each waste. The constituents that compose these waste codes are organophosphorous compounds. These wastes also appear to be able to be treated to similar concentrations using the same technology; therefore, the Agency combined these codes into one treatability group.

P039: Disulfoton
P040: O,O-diethyl O-pyrazinyl phosphorothioate
P041: Diethyl-P-nitrophenyl phosphate
P043: Diisopropyl fluorophosphate (DEP)
P044: Dimethoate
P062: Hexaethyl tetraphosphate
P071: Methyl parathion
P085: Octamethylpyrophosphoramide
P089: Parathion
P094: Phorate
P097: Famphur
P109: Tetraethyl dithiopyrophosphate
P111: Tetraethyl pyrophosphate
U059: Cyclophosphamide
U087: O-O-diethyl-5-methyl-dithiophosphate
U235: 1-propanol, 2,3-dibromo-,phosphate (3:1)

According to 40 CFR 261.33, the above-mentioned materials are hazardous wastes when they are discarded or are intended to be discarded; when they are mixed with waste oil, used oil, or another material; and when they are applied to the land or are contained in products that are applied to the land, and when burned as fuel.

These materials can be present in different forms. These forms include:

- Any commercial or off-specification commercial chemical product with any of the above generic names;
- Residues remaining in containers that held any of the above-mentioned products; or
- The residue of contaminated soil, water, or other debris that results when there is a cleanup of a commercial or off-specification commercial chemical product or manufacturing chemical intermediate having the generic name of any of the above-listed products that had been spilled onto the land or into the water.

8.1 Industry Affected

Table 8-1 presents the number of RCRA permitted facilities that generated the above-listed wastes and the approximate volumes produced in 1986 (CBI information is not included). The Agency estimates that about 142,797 gallons of these wastes were generated in 1986.

Even though all wastes conform to one treatability group and the same treatment technology can be applied to these wastes, the Agency believes that the above-listed wastes can be divided into two separate groups for the purpose of determining the BDAT treatment standards. The first group includes the P and U wastes for which numerical standards can be established. These wastes are structurally similar to K037. The transfer of treatment standards for disulfoton from K037 is particularly appropriate for P039 (disulfoton) and for P094 (phorate). The only structural difference between phorate and disulfoton is the additional methylene ($-CH_2-$) group in disulfoton. This slight difference is believed to be insignificant with respect to the ability of the two

Table 8-1 Number of Facilities and Volume of Organophosphorous P and U Wastes Generated in 1986

Waste code	No. of facilities	Volume produced (gallons)
P039	2	13,920
P040	2	270
P041	1	1
P043	2	2
P044	7	19,252
P062	0	0
P071	5	40,328
P085	1	1
P089	7	52,801
P094	2	14,880
P097	0	0
P109	0	0
P111	0	0
U058	2	380
U087	1	961
U235	1	1

Reference: USEPA 1986b.

pesticides to be incinerated. EPA thus believes the structural similarity is sufficient to support the transfer of standards. The wastes considered under this group are the following:

P039: Disulfoton
P071: Methyl parathion
P089: Parathion
P094: Phorate
P097: Famphur
U235: 1-propanol, 2.3-dibromo-,phosphate (3:1)

The second group includes those P and U wastes for which numerical standards cannot be set. Methods to analyze the listed constituents in these wastes in treatment residues are not currently available. Although the Agency recognizes that these compounds exist and that the manufacturers may have methods to verify their purity and determine their product specifications, there are no EPA-approved analytical procedures to ascertain trace quantities of these chemicals either in the raw sample or in the residues from treatment. In addition, EPA has not identified any organic constituents in these wastes that could be used as a surrogate or as an indicator compound in order to develop numerical standards for these wastes. The wastes considered under this group are the following:

P040: O,O-diethyl O-pyrazinyl phosphorothioate
P041: Diethyl-P-nitrophenyl phosphate
P043: Diisopropyl fluorophosphate (DEP)
P044: Dimethoate
P062: Hexaethyl tetraphosphate
P085: Octamethylpyrophosphoramide
P109: Tetraethyl dithiopyrophosphate
P111: Tetraethyl pyrophosphate
U058: Cyclophosphamide
U087: O-O-diethyl-5-methyl-dithiophosphate

The constituents in P041, P044, and P111 wastes hydrolyze in water, which make them difficult to analyze. The Agency currently does not have information on the rates of hydrolysis of these constituents or the products resulting from the hydrolysis reactions and their effects on the environment.

The listed constituents in P062, P085, and U058 wastes can only be analyzed using High Performance Liquid Chromatography (HPLC) techniques. The HPLC techniques are not recommended for measuring concentrations in complex matrices; therefore, it would not be possible to determine the treatability level in the residuals of these wastes if the HPLC methods were used. The Agency has not approved such techniques for measuring constituent concentrations in complex matrices.

Analytical standards do not appear to be available for the listed constituents in P040, P109, and U087 wastes.

8.2 Identification of Best Demonstrated Available Technology

The Agency believes that the constituent for which P039 (disulfoton) is listed is one of the most difficult organophosphorous chemicals to incinerate in this entire group of organophosphorous compounds. Since the constituents in this group are structurally similar, the Agency believes that all wastes in this treatability group can be effectively treated by incineration.

The Agency believes that all P and U wastes listed in this section can be present in both wastewater and nonwastewater forms. Therefore, the Agency has developed treatment standards for both of these forms.

The nonwastewater streams may be the raw waste as generated and the residuals after treatment. The wastewater residuals may be the raw waste as generated.

8.2.1 Nonwastewaters

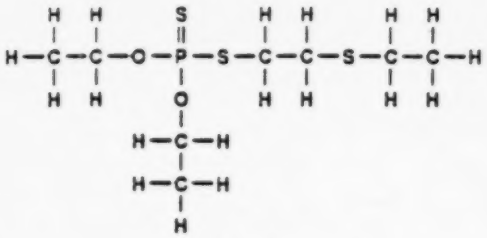
Based on the analysis performed for K037 (see Section 5.1) and the belief that P039, P071, P089, P094, P097, and U235 wastes are structurally similar to K037, the Agency considers incineration to be BDAT for the nonwastewater forms of these wastes. The Agency has no reason to believe that the above-mentioned wastes cannot be treated to nondetectable levels in the ash that results from incineration of these wastes. The bond dissociation energies of these constituents are lower than that of disulfoton (K037 waste constituent), and the chemical structures of these wastes are similar to the structure of disulfoton (see Figure 8-1). These characteristics affecting performance of incineration of these wastes show that P039, P071, P089, P094, P097, and U235 wastes should be more readily incinerable than K037. Therefore, the Agency has concluded that since the above-mentioned wastes are similar to K037, incineration is demonstrated and was selected for determination of BDAT treatment standards for all nonwastewaters associated with the treatment of P039, P071, P089, P094, P097, and U235 wastes. As with K037 treatment residuals, the Agency concluded that there is no need for additional treatment of nonwastewater and wastewater residuals of the above-mentioned treated wastes.

The Agency has also proposed incineration as BDAT for the nonwastewater forms of the remaining wastes--P040, P041, P043, P044, P062, P085, P109, P111, U058, and U087. The Agency does not have performance data on the above-mentioned wastes, but believes that incineration should destroy or reduce the total amount of organic compounds in these wastes because these wastes are part of the treatability group with similar chemical structures, lower bond dissociation energies, and lower boiling points than those for the constituent in the similar waste (K037).

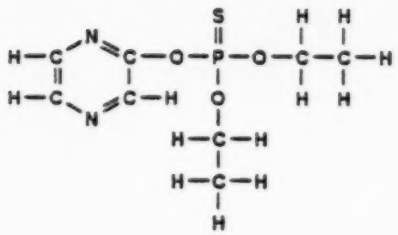
8.2.2 Wastewaters

Since the Agency has already determined that incineration is BDAT for similar K037 wastewaters, EPA has decided to propose incineration as BDAT for the wastewater forms of P039, P071, P089, P094, P097, and U235 wastes. Performance data for K037 indicated that concentrations of BDAT list organic constituents in scrubber water from incineration were below detection limits. Consequently, additional treatment of scrubber water would not improve upon this performance.

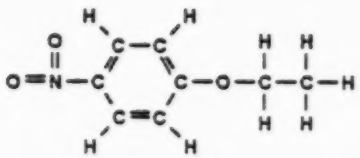
The Agency has proposed carbon adsorption as BDAT for the wastewater forms of P040, P041, P043, P044, P062, P085, P109, P111, U058, and U087. The Agency believes that these wastewaters can be easily adsorbed because of the branched nature of their structures (see Figure 8-1). Following adsorption, the resulting carbon residual must be incinerated and the standards for the nonwastewater must be met.



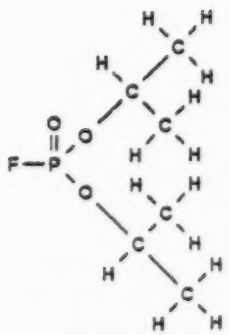
P039: DISULFOTON



P040: O,O-DIETHYL O-PYRAZINYL PHOSPHOROTHIOATE

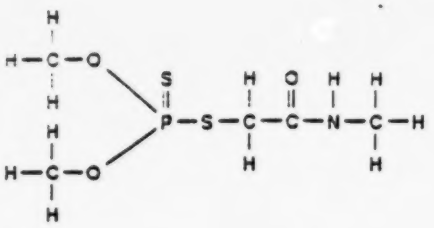


P041: DIETHYL P-NITROPHENYL PHOSPHATE

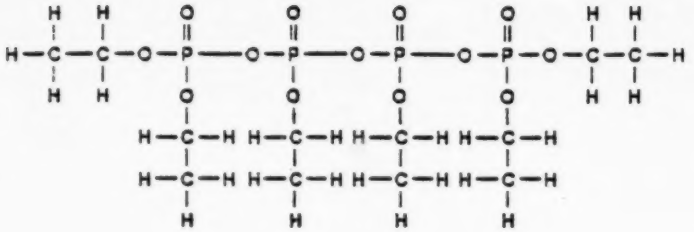


P043: DIISOPROPYL FLUOROPHOSPHATE

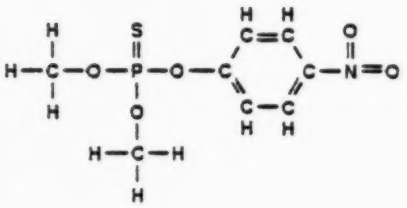
FIGURE 8-1 CHEMICAL STRUCTURES FOR P AND U WASTES



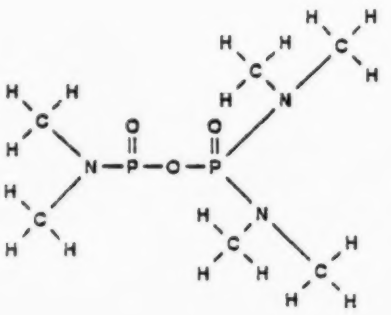
P044: DIMETHOATE



P062: HEXAETHYL TETRAPHOSPHATE

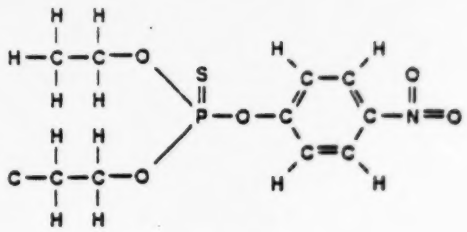


P071: METHL PARATHION

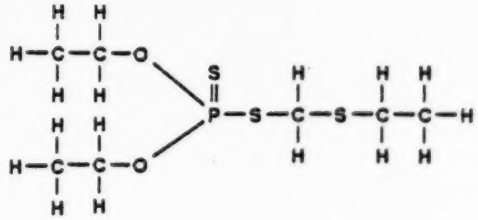


P085: OCTAMETHYLPYROPHOSPHORAMIDE

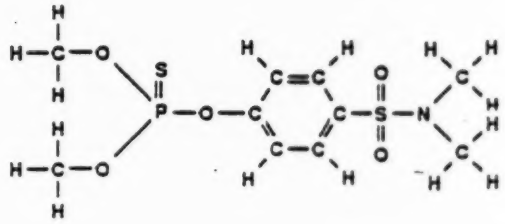
FIGURE 8-1(CONTINUED) CHEMICAL STRUCTURES FOR P AND U WASTES



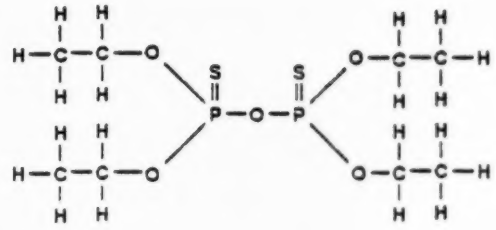
P089: PARATHION



P094: PHORATE

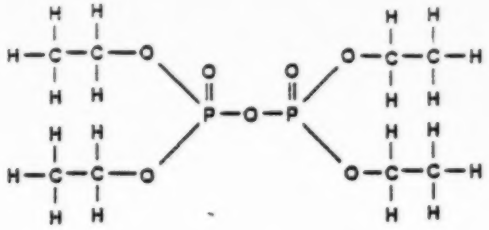


P097: FAMPHUR

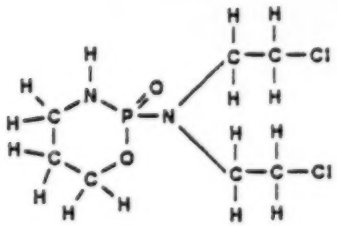


P109: TETRAETHYLDITHIOPYROPHOSPHATE

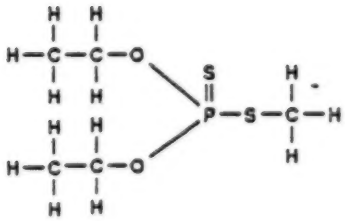
FIGURE 8-1(CONTINUED) CHEMICAL STRUCTURES FOR P AND U WASTES



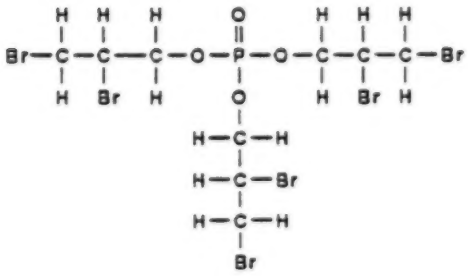
P111: TETRAETHYL PYROPHOSPHATE



U058: CYCLOPHOSPHAMIDE



U087: O-O-DIETHYL-S-METHYL-DITHIOPHOSPHATE



U235: 1-PROPANOL, 2,3-DIBROMO-, PHOSPHATE (3:1)

FIGURE 8-1(CONTINUED) CHEMICAL STRUCTURES FOR P AND U WASTES

8.3 Treatment Standards

The treatment standards for the nonwastewater and wastewater forms of P039, P071, P089, P094, P097, and U235 wastes have been directly transferred from the nonwastewater and wastewater forms of K037 and are presented in Tables 8-2 and 8-3.

The Agency is proposing technology-based standards for P040, P041, P043, P044, P062, P085, P109, P111, U058, and U087. For these wastes the Agency is proposing that nonwastewaters be incinerated and that wastewaters be treated by activated carbon adsorption followed by incineration of the spent carbon. As discussed in Section 8-1, it is not possible for the Agency to set performance treatment standards for the above-listed wastes at this time.

Table 8-2 BDAT Nonwastewater Treatment Standards for P039, P071, P089, P094, P097, and U235

Regulated constituents	K037 const. from which treat. data were transferred	Untreated conc. in K037 (ppm)	Arithmetic average of corrected treat. values (ppm)	Variability factor (VF)	Treatment standard (Ave. x VF) (ppm)
Organophosphorous Insecticide					
P039: Disulfoton	Disulfoton	104,000-246,000	0.04	2.8	0.1
P071: Methyl parathion	Disulfoton	104,000-246,000	0.04	2.8	0.1
P089: Parathion	Disulfoton	104,000-246,000	0.04	2.8	0.1
P094: Phorate	Disulfoton	104,000-246,000	0.04	2.8	0.1
P097: Famphur	Disulfoton	104,000-246,000	0.04	2.8	0.1
U235: Tris-BP	Disulfoton	104,000-246,000	0.04	2.8	0.1

Table 8-3 BDAT Wastewater Treatment Standards for P039, P071, P089, P094, P097, and U235

Regulated constituents	K037 const. from which treat. data were transferred	Untreated conc. in K037 (ppm)	Arithmetic average of corrected treat. values (ppm)	Variability factor (VF)	Treatment standard (Ave. x VF) (ppm)
Organophosphorous Insecticide					
P039: Disulfoton	Disulfoton	104,000-246,000	0.0011	2.8	0.003
P071: Methyl parathion	Disulfoton	104,000-246,000	0.0011	2.8	0.003
P089: Parathion	Disulfoton	104,000-246,000	0.0011	2.8	0.003
P094: Phorate	Disulfoton	104,000-246,000	0.0011	2.8	0.003
P097: Famphur	Disulfoton	104,000-246,000	0.0011	2.8	0.003
U235: Tris-BP	Disulfoton	104,000-246,000	0.0011	2.8	0.003

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